Use Case for computing Integrated Kinetic Energy (IKE)

Mark Powell

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Summary

Recent research on new measures of intensity compute integrated kinetic energy from the surface wind field. Damage potential ratings are based on a 1-5 scale with 5 being the most severe. A storm surge/waves damage potential metric is based on the sum of KE values of volume elements associated with marine exposure wind analysis grid cells in which the wind speeds are >= 33 m/s. A wind damage potential metric is based on contributions from winds of >= 25 and < 41 m/s, >=41 and < 55 m/s, and >= 55 m/s. IKE values for winds in excess of tropical storm and hurricane force are also computed.

1. Kinetic Energy (KE) Calculation

Input: wind speed at each ***marine gridded field*** grid point, size of grid interval or spacing in km

for every cell with a marine exposure wind speed >= 18 m/s

a. WS = SQRT (U^2 + V^2)

b. KE = 0.5 * WS^2 * DG^2 * Z

Where

U = east-west wind component (m/s)

V = North-south wind component (m/s)

WS = Wind Speed in m/s

DG = Grid interval in meters

Z = vertical thickness of grid volume element (use Z = 1 m)

2. IKE_{TS} = Sum (all KE values for winds >= 18 m/s) / 10^{12}

Note: Dividing by 10^{12} results in Terra Joules (TJ)

3. $IKE_{25\text{-}40}$ = Sum (all KE values for winds >= 25 m/s and < 41 m/s) / 10^{12}

4. IKE_{H} = Sum (all KE values for winds >= 33 m/s) / 10^{12}

5. $IKE_{41\text{-}54}$ = Sum (all KE values for winds >= 41 m/s and < 55 m/s) / 10^{12}

6. $IKE_{\mathbf{55}}$ = Sum (all KE values for winds >= 55 m/s) / 10^{12}

7. Storm Surge and Wave Destructive Potential Rating (S_{DP})

IF at least one grid point wind speed is >= 18 m/s:

$$S_{DP} = 0.676 + 0.43\sqrt{IKE_{TS}} - 0.0176\left(\sqrt{IKE_{TS}} - 6.5\right)^2$$

Else: S_{DP} =0.0

8. Wind Destructive Potential Rating W_{DP}

IF at least one grid point wind speed is >= 55 m/s:

$W_{DP>4} = 3.28 + 1.007 * \text{Log}_{10}(30\ IKE_{55}) + 0.271 * (\text{Log}_{10}(30\ IKE_{55}) - 1.629)^2$

IF $W_{DP>4}$ < 0.0 set = 0.0

Else if at least one grid point wind speed is >= 25 m/s and no grid point winds >= 55 m/s

$W_{DP<4}$ = 0.67 + .017 ($IKE_{25\text{-}40}$+ 6 $IKE_{41\text{-}54}$)
- $5.4e^{-5}$ (($IKE_{25\text{-}40}$+ 6 $IKE_{41\text{-}54}$) - 109.6)) ^ 2

Else W_{DP} =0.0

IF $W_{DP<4}$ < 0.0 set = 0.0

9. Product Annotations

These four values would be added to the analysis image or annotation surrounding the image

Integrated Kinetic Energy >TS: 200 TJ >Hurricane: 50 TJ

Destructive Potential Rating (0-6) Wind: 3.5 Surge/Waves: 2.1

10a. **H*Wind radii database**

Saving calculations to a file (or better yet database)

For each analysis conducted, I would like to see the calculations stored and associated with the analysis. In addition I would like the wind radii stored for each quadrant. The file would contain the following entries:

Storm Name, year, date, time(UTC), Analyst, Pmin, Max OB wind, RmaxOb (KM), Max Analysis Wind, Rmax analysis, R_{TS}NW, R_{TS}NE, R_{TS}SE, R_{TS}SW, R_{50}NW,R_{50}NE, R_{50}SE, R_{50}SW, R_{64}NW, R_{64}NE, R_{64}SE, R_{64}SW, IKE_{TS}, IKE_{H}, $IKE_{25\text{-}40}$, $IKE_{41\text{-}54}$, IKE_{55}, W_{DP}, S_{DP}

10b. **NHC Operational radii CarQ database:**

We will need to join this with a database containing the NHC advisory information every 6 h or 3 h during a warning. These data may be in the CarQ files

Storm Name, year, date, time(UTC), Pmin, Max wind, Rmax, R_{TS}NW, R_{TS}NE, R_{TS}SE, R_{TS}SW, R_{50}NW,R_{50}NE, R_{50}SE, R_{50}SW, R_{64}NW, R_{64}NE, R_{64}SE, R_{64}SW

Then add to this the calculations of IKE based on the Appendix from the IKE paper:

IKE_{TS}, IKE_{H}, $IKE_{25\text{-}40}$, $IKE_{41\text{-}54}$, IKE_{55}, W_{DP}, S_{DP}

11. Once the calculations check out we need to go back through all our operational gridded files to add the contents to the database and make the database available on the web. Hopefully you could write some code that will crank through the marine gridded files in batch mode

12. Sample Calculations Table:

Storm	YYYY	MM-dd	Time (UTC)	Rmax (km)	Pmin (hPa)	MSW ($m\ s^{-1}$)	R18 S(km)	R26 (km)	R33 (km)	WDP	SDP	IKE_{10}	IKE_{TS}	IKE_{H}	$IKE_{25\text{-}40}$	$IKE_{40\text{-}55}$	$IKE_{>55}$	SS	HII
Andrew	1992	9-24	0900	19	922	68	191	142	77	5.0	2.5	40	20	7	7	3	2	5	5.2
Camille	1969	8-18	0430	15	909	67	218	157	109	5.2	4.0	78	63	31	32	14	3	5	5.0
Charley	2004	8-13	1930	7	941	63	156	81	40	4.1	1.9	24	11	2	5	1	0	4	4.1
Dennis	2005	7-10	1930	9	946	55	296	77	33	0.3	3.4	77	40	2	7	1	0	3	2.7
Emily	2005	7-20	0130	24	948	54	291	168	86	1.7	4.2	105	70	14	39	4	0	3	3.0
Fabian	2003	9-05	1330	67	941	51	380	241	138	3.7	5.1	165	123	40	61	21	0	3	3.0
Frances	2004	9-05	0130	52	960	46	319	217	139	2.5	4.7	124	94	29	53	8	0	2	2.0
Hugo	1989	9-22	0400	37	934	58	317	235	146	4.7	4.7	110	95	25	51	9	1	4	3.5
Iris	2001	10-09	0130	8	948	66	165	93	37	0.1	1.3	8	5	1	2	0	0	4	3.8

Storm	YYYY	MM-dd	Time (UTC)	Rmax (km)	Pmin (hPa)	MSW ($m\ s^{-1}$)	R18 S(km)	R26 (km)	R33 (km)	WDP	SDP	IKE_{10}	IKE_{TS}	IKE_{H}	IKE_{25-40}	IKE_{40-55}	$IKE_{>55}$	SS	HII
Isabel	2003	9-18	1630	87	957	47	532	322	214	3.4	5.6	212	174	42	93	12	0	2	1.9
Ivan_AL	2004	9-16	0730	35	946	49	326	206	128	2.2	4.4	109	81	26	46	7	0	3	2.7
Ivan_Jam	2004	9-11	1330	17	925	71	314	196	121	5.6	4.7	142	95	32	43	11	6	4	3.8
Jeanne	2004	9-26	0330	48	950	46	317	201	131	1.9	4.3	109	73	21	39	6	0	3	2.7
Katrina FL	2005	8-25	2230	15	984	33	115	44	28	0.1	1.3	27	5	0	2	0	0	1	1.2
Katrina LA	2005	8-29	1200	65	920	53	454	311	217	3.7	5.1	151	122	49	68	21	0	3	3.0
Katrina Peak H*Wind	2005	8-28	1200	26	909	72	349	218	139	5.8	5.1	166	124	45	58	16	7	5	5.2
Keith BLZ	2000	10-01	2230	19	959	51	154	62	44	0.5	1.9	20	11	4	4	2	0	3	2.4
Michelle	2001	11-04	1930	28	949	60	335	120	80	1.7	4.0	109	61	14	16	8	0	4	3.5
Opal	1995	10-04	2235	98	942	50	353	191	169	3.5	5.0	173	119	38	46	21	0	3	2.4
Rita	2005	9-24	0730	30	937	50	357	230	174	2.6	4.3	104	74	32	39	12	0	3	2.4
Wilma Peak H*Wind	2005	10-19	1930	7	892	66	326	97	53	4.6	4.2	132	70	7	13	4	1	5	4.8
Wilma FL	2005	10-24	1030	72	951	52	380	268	179	2.8	4.8	153	104	29	48	12	0	2	2.5
Wilma MX	2005	10-22	0130	20	930	59	394	220	121	4.7	5.1	170	121	28	49	13	1	4	3.2